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LISTS OF SPECIES

Metazoan parasite fauna of two peacock-bass cichlid fish in Brazil

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ABSTRACT: A parasitological study of two freshwater cichlid fish of the genus *Cichla* (*C. kelberi* and *C. piquiti*) from six different aquatic ecosystems in Brazil was performed. Based on the survey, a checklist of the component community of the metazoan parasites of each of the two peacock-bass fish species was produced. Fish were collected from May 2009 to April 2011 in six Brazilian aquatic ecosystems using gillnets of different mesh sizes or angling using standardized effort. In total, six groups of parasites were collected: Monogenea, Digenea, Cestoda, Nematoda, Copepoda and Branchiura. Among the groups of parasites found, nematodes presented the greatest number of species, with seven. The study lists new records of parasites in *C. kelberi* and *C. piquiti*, and new biogeography records of parasites in six different aquatic ecosystems in Brazil. The present paper collaborates with the study of conservation biology by adding new records of parasite species.

INTRODUCTION

Species of the genus *Cichla* are commonly called peacock-bass in English or tucunaré in Portuguese, accounting for the major piscivorous fish of the Cichlidae family in South America (Lowe-McConnell 1975). They are very popular as sport fish, due to their great voracity in attacking natural or artificial baits and high resistance after being hooked by anglers (Shafland 1996).

This genus is widely distributed in the Amazon, Tocantins and Orinoco river basins, and in the smaller rivers draining the Guianas to the Atlantic Ocean. Within South American transplantations, they are recorded in Paraná and Paraguay River drainages in Paraguay and Brazil, and in Paraíba do Sul and Paraguaçu rivers in Brazil (Kullander and Ferreira 2006). The introduction of these organisms aimed to increase sport fishing, pisciculture and the population control of undesirable and/or highly prolific species (Fontenele and Peixoto 1979; Oliveira *et al.* 1986). Following their introduction, as a consequence, the peacock-bass dominated in many ecosystems, causing imbalance by demonstrating high competitiveness (Agostinho *et al.* 2007) and significant ability to reduce populations of native fish (Pelicice and Agostinho 2009).

Studies on parasitic fauna of the genus *Cichla* have been performed for native populations of the Amazon basin (Kritsky *et al.* 1989; Thatcher 2006; Araujo *et al.* 2009) and introduced populations in the Paraná River (Takemoto and Pavanelli 1996; Machado *et al.* 2000; Santos *et al.* 2002) and in the Volta Grande reservoir, Grande river, Minas Gerais (Martins *et al.* 2009). Studies identifying new hosts and new localities for parasites have contributed to the knowledge of local biodiversity as well as the understanding of the evolution of parasites and their hosts (Lacerda *et al.* 2008). The main purpose of this study was to perform a survey of the metazoan parasites of two peacock-bass fish species from six different aquatic ecosystems in Brazil.

MATERIALS AND METHODS

Fish were collected from May 2009 to April 2011 from six Brazilian aquatic ecosystems: Marechal Dutra dam (Acauã River) (6°26′11″S, 36°36′17″W); Lajeado reservoir (Tocantins River) (9°75′14″S, 48°35′75″W); São Salvador reservoir (Tocantins River) (12°74′75″S, 48°24′09″W); Jupiá reservoir (Paraná River) (20°75′98″S, 51°69′50″W); Itaipu reservoir (Paraná River) (25°40′80″S, 54°58′92″W); and Rosana reservoir (Paranapanema River) (22°36′08″S, 52°52′22″W) (Figure 1).

Two species of peacock fish were sampled: *Cichla kelberi* Kullander and Ferreira, 2006 and *C. piquiti* Kullander and Ferreira, 2006. Hosts were collected using gillnets of different mesh sizes or angling using standardized effort. After sampling, the gills of the selected individuals were studied for ectoparasites, and the body cavity was opened to examine the liver, stomach, pyloric caeca, intestine and gonads for endoparasites (see Eiras *et al.* 2006). Sampling, fixation and preservation of parasites were done according to Eiras *et al.* (2006). Identification of the parasites followed Kritsky *et al.* (1986, 1989), Moravec (1998) and Thatcher (2006). Voucher specimens of parasite species were deposited in the Coleção Helmintológica do Instituto de Biociências de Botucatu (CHIBB), Universidade Estadual Paulista, São Paulo State, Brazil.

RESULTS AND DISCUSSION

A total of 161 specimens of *Cichla*, 95 *C. piquiti* (13 from Jupiá reservoir, 27 from Itaipu reservoir, 25 from Lajeado reservoir and 30 from São Salvador reservoir) and 66 *C. kelberi* (21 from Jupiá reservoir, 29 from Rosana reservoir and 16 from Marechal Dutra dam), were examined.

The component community of *C. kelberi* was composed of four taxonomic groups (Monogenea, Digenea, Cestoda and Nematoda), totalling 863 parasite specimens belonging to 11 taxa, in which *Proteocephalus microscopicus* (Cestoda) and *Contracaecum* sp. (larvae) (Nematoda)

were the most prevalent (Table 1). *Cichla piquiti* showed a richer and more abundant component community than *C. kelberi* (Monogenea, Digenea, Cestoda, Nematoda, Copepoda and Branchiura), totalling 21,141 specimens of parasites belonging to 17 taxa, with *P. microscopicus* (Cestoda) and *Gussevia tucunarense* (Monogenea) being the most prevalent (Table 2).

Lists of parasite species

PHYLUM PLATYHELMINTHES Gegenbaur, 1859

Class Monogenea Van Beneden, 1858

Order Dactylogyridea Bychowsky, 1937

Family Dactylogyridae Bychowsky, 1933

Genus *Sciadicleithrum* Kritsky, Thatcher and Boeger, 1989

Sciadicleithrum ergensi Kritsky, Thatcher and Boeger, 1989 — CHIBB 104L, 105L, 106L

Sciadicleithrum uncinatum Kritsky, Thatcher and Boeger, 1989 — CHIBB 110L, 111L

Sciadicleithrum umbilicum Kritsky, Thatcher and Boeger, 1989 — CHIBB 118L, 119L

According to Kritsky *et al.* (1989), the genus *Sciadicleithrum* is a Neotropical monogenean, its representatives parasitizing only species of cichlid fishes. Since the genus was first recorded, 13 additional species have been described, totalling 22 species to date. In the present study, *S. uncinatum* and *S. umbilicum* parasitized only *C. piquiti* and *S. ergensi* parasitized both host species.

Genus *Gussevia* Kohn and Paperna, 1964

Gussevia tucunarense Kritsky, Thatcher and Boeger, 1986 — CHIBB 107L, 108L, 109L

Gussevia undulata Kritsky, Thatcher and Boeger, 1986 — CHIBB 114L

The genus *Gussevia* parasitizes cichlid fishes of the Neotropical region. Currently, there are 17 valid species in this genus. Despite being parasites of cichlid fishes such as *Sciadicleithrum*, monogenean species of this genus have a differently shaped haptor with anterior and posterior lobes, hooklets pair 5 with a different morphology. *Gussevia tucunarense* and *G. undulata* parasitized both host species in the present study.

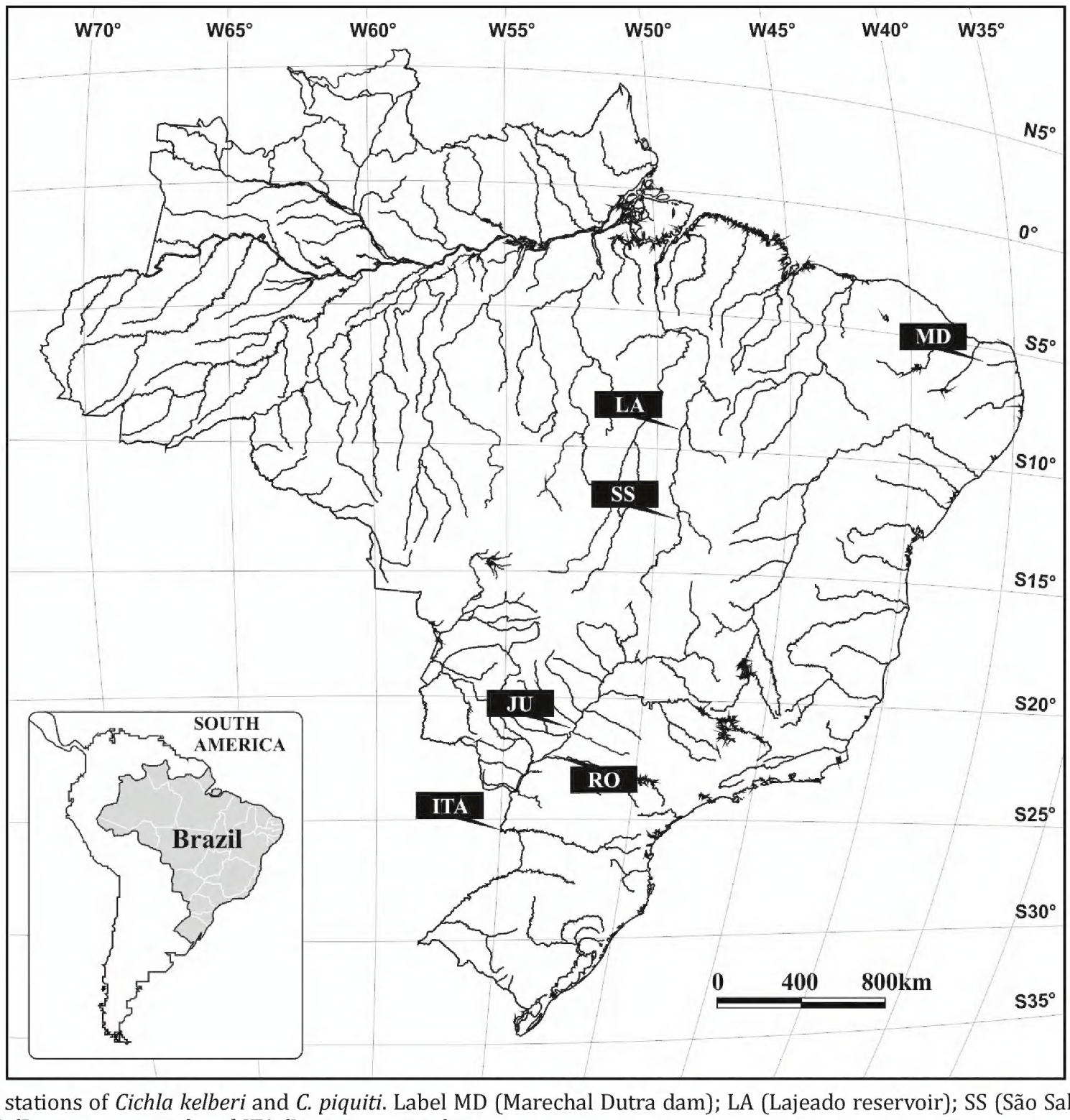

Figure 1. Sampling stations of *Cichla kelberi* and *C. piquiti*. Label MD (Marechal Dutra dam); LA (Lajeado reservoir); SS (São Salvador reservoir); JU (Jupiá reservoir); RO (Rosana reservoir) and ITA (Itaipu reservoir).

Class Trematoda Rudolphi, 1808

Subclass Digenea Carus, 1863

Family Heterophyidae Odhner, 1914

Genus *Ascocotyle* Looss, 1899

Ascocotyle sp. (metacercariae) — CHIBB 112L, 113L

Ascocotyle sp. has been already registered, parasitizing many host fish and reaching broad biogeographical distribution (Scholz *et al.* 1997). Scholz (1999) examined an extensive material and revealed numerous misidentifications of specimens in museum collections and showed a striking similarity between some taxa. Despite their common occurrence, the taxonomy of trematodes of the family Heterophyidae still remains unsatisfactory (Scholz, 1999).

Family Diplostomidae Poirier, 1886

Genus *Sphincterodiplostomum* Dubois, 1936

Sphincterodiplostomum sp. (metacercariae)

According to Lunaschi and Drago (2006), specimens of *Sphincterodiplostomum* are parasites of the intestine of Neotropical birds. They are monospecific and differ from other genera of the family Diplostomidae by the presence of a dorsal tubular invagination equipped with a sphincter, in the posterior testis. The original description was based on the morphology of immature specimens collected from the intestine of *Agamia agami* (Gmelin, 1789) (Ardeidae), in Mato Grosso, Brazil. There are records of this parasite in fish organs such as: eyes of *Cyphocharax gilbert* Quoy and Gaimard, 1824 from the Guandu River (Abdallah *et al*. 2005) and *Hoplias malabaricus* Bloch, 1794 from the Upper Paraná River floodplain (Takemoto *et al*. 2009); in the ovary of *Steindachinerina brevipinna* Eigenmann and Eigenmann, 1889 from the Paranapanema River (Ceschini *et al.* 2010); and the visceral cavity of *Hemisorubim platyrhynchos* (Valenciennes, 1840) from the Upper Paraná River floodplain (Guidelli *et al.* 2003). The current study recorded *Sphincterodiplostomum* sp. only in *C. piquiti* collected from the Itaipu reservoir.

Family Derogenidae Nicoll, 1910

Genus *Genarchella* Travassos, Artigas and Pereira, 1928

Genarchella genarchella Travassos, Artigas and Pereira, 1928

Genarchella genarchella is a type species and parasitizes upper regions of the gut (usually the stomach) of freshwater fish from South and Central America (Thatcher 2006). In the present study *G. genarchella* parasitized only *C. piquiti* collected from São Salvador reservoir.

Class CestodaVan Beneden, 1849

Order Proteocephalidea Mola, 1928

Family Proteocephalidae La Rue, 1914

Genus *Proteocephalus* Weinland, 1858

Proteocephalus microscopicus (Woodland, 1935) — CHIBB 7167

Proteocephalus macrophallus (Diesing, 1850) — CHIBB 7166

Proteocephalids are the most numerous and important helminths in freshwater fish and approximately 80 species have been described in freshwater fish from South America, mostly found in Siluriformes (Rego *et al.* 1999a). Proteocephalid tapeworms have been studied in several fish species from the Paraná River (Santos *et. al.* 2011), and *P. microscopicus* and *P. macrophallus* were specific of cichlid fish recorded in both hosts of the present study.

Subfamily Corallobothriinae Freze, 1965

Genus *Sciadocephalus* Diesing, 1850

Sciadocephalus megalodiscus Diesing, 1850 — CHIBB 7169

Sciadocephalus megalodiscus was described by Diesing in 1850 parasitizing *Cichla monoculus* (Bloch and Schneider, 1801) from Mato Grosso State, Brazil, and redescribed by Woodland in 1933 parasitizing the same fish species in Brazilian Amazonia. Rego *et al.* (1999b) recorded *S. megalodiscus* parasitizing *Cichla monoculus* (*Cichla kelberi* is the valid species) collected in the Paraná River, Brazil. According to Rego (1994), there were doubts about the subfamily to which this species belonged, given that the position of the reproductive organs (a fundamental character to classify the taxon) was unclear, and it was rather treated as a species inquirenda.

PHYLUM NEMATODA Rudolphi, 1808

Class Secernentea Von Linstow, 1905

Order Spirurida Diesing, 1861

Family Camallanidae Railliet and Henry, 1915

Genus *Procamallanus* Baylis, 1923

Subgenus *Procamallanus (Procamallanus)* Baylis, 1923

Subgenus *Procamallanus (Spirocamallanus)* Baylis, 1923

Nematodes of the genus *Procamallanus* parasitize freshwater and marine fish, and are composed of

the two subgenera *Procamallanus* Baylis, 1923 and *Spirocamallanus* Olsen, 1952. The difference between the two subgenera is basically the aspect of the buccal capsule. Thus, *Spirocamallanus* presents a buccal capsule with spiral thickenings and *Procamallanus* shows a smooth buccal capsule. According to Thatcher (2006), *Spirocamallanus* is probably polyphyletic and may require division into several genera.

Procamallanus (Procamallanus) peracuratus Magalhães Pinto, Fábio, Noronha and Rolas, 1976 — CHIBB 7165

This species was described parasitizing two cichlid fishes: *Geophagus brasiliensis* (Quoy and Gaimard, 1824) (type host) and *Cichlasoma facetum* (Jenyns, 1842). Later, it was found in *Crenicichla lepidota* Heckel, 1840. According to Moravec (1998), it is a parasite mainly in Cichlidae and occasional findings have been reported also from *Pimelodus ortmanni* Haseman, 1911 (Pimelodidae) and *Potamotrygon motoro* (Müller and Henle, 1841) (Potamotrygonidae). The present study registered *P. (P.) peracuratus* for the first time parasitizing *C. kelberi* from the Jupiá reservoir.

Procamallanus (Spirocamallanus) rarus Travassos, Artigas and Pereira, 1928

Procamallanus (Spirocamallanus) rarus was described parasitizing the intestine of *Pimelodella lateristriga* (Lichtenstein 1823) (type host) and *Rhynodoras dorbignyi* (Kroyer, 1855) in the region of Pirassununga, São Paulo State. Others host species include *Pimelodus albicans* Valenciennes, 1840, *P. clarias* (Bloch 1782), *P. maculatus* Lacépède, 1803, *Ageneiosus ucayalensis* Castelnau, 1855 and *Satanoperca jurupari* Heckel, 1840 (Moravec 1998; Giese *et al.* 2009; Melo *et al.* 2012). This is the first record of *P. (S.) rarus* parasitizing *C. piquiti* and also the first record in the Paraná River.

Procamallanus (Spirocamallanus) inopinatus Travassos, Artigas and Pereira, 1928 — CHIBB 7171

Takemoto *et al.* (2009) reported this species in nine different species of hosts in the Upper Paraná River floodplain, Paraná State, Brazil. Moravec (1998) had already registered this species in more than 40 host species, presenting a wide distribution in South American freshwater fish. Araujo *et al.* (2009) first reported *P. (S.) inopinatus* in *C. kelberi* collected in Piauí State, Brazil. The current study reported for the first time the occurrence of this nematode parasitizing *C. piquiti* from São Salvador reservoir.

Order Ascaridida Skrjabin and Schulz, 1940

Family Cucullanidae Cobbold, 1864

Genus *Cucullanus* Müller, 1777

Cucullanus sp.

Cucullanus includes approximately 100 species, all parasites of fish around the world (Timi and Lanfranchi 2006). According to Giese *et al.* (2010) there are 26 known Neotropical species of *Cucullanus* reported in South America, of which 16 species have been described in Brazil (10 occur in freshwater, five in marine environments and only one species has been described for brackish waters).

Family Anisakidae Railliet and Henry, 1912

Genus *Goezia* Zeder, 1800

Goezia intermedia Rasheed, 1965 — CHIBB 7168

Goezia intermedia is one of the five species of the *Goezia* genus and parasitizes Neotropical freshwater fish. This species has been described parasitizing *C. ocellaris* Bloch and Schneider, 1801 (Cichlidae) from Guyana (Georgetown) (Moravec 1998). The present paper reports for the first time *G. intermedia* parasitizing *C. kelberi* and also the first record of it in the Paraná River.

Genus *Raphidascaris* Railliet and Henry, 1915

Raphidascaris (*Sprentascaris*) *mahnerti* (Petter and Cassone, 1984) — CHIBB 7172

This species parasitizes armoured catfish. This nematode has been registered as *Loricaria* sp., *Loricariichthys* sp., *L. rostratus* Reis and Pereira, 2000, *Pseudohemiodon laticeps* (=*Loricaria laticeps* Regan, 1904) in the reservoir of the hydroelectric power plant of Itaipu, Brazil (Kohn *et al.* 2011), and *Loricariichthys platymetopon* Isbrücker and Nijssen, 1979 in the upper Paraná River floodplain (Takemoto *et al.* 2009). In addition to armoured catfish, *R.* (*S.*) *mahnerti* has been found to parasitize *Metynnis lippincottianus* Cope, 1878 (Characidae) (Moreira *et al.* 2009), *Geophagus proximus* (Castelnau, 1855) (Cichlidae) (Takemoto *et al.* 2009) and *C. kelberi* (Cichlidae) (present study). Moravec *et al.* (1993) reported a larva from the intestine of the cichlid *Geophagus brasiliensis* (Quoy and Gaimard, 1824), supposing that this fish probably serves as a paratenic host.

Genus *Contracaecum* Railliet and Henry, 1912 — larvae — CHIBB 7170

Adult nematodes of this genus parasitize the digestive tract of birds and marine mammals, while their larvae are often found in the internal organs of fishes serving either as an intermediate or paratenic host (Moravec 1998). In fish hosts the taxonomics and systematics of this parasite are insufficient. *Contracaecum* spp. (larvae) was recorded in more than 70 hosts of the Neotropical region and in central Mexico. In the present study, this nematode was present in both fish hosts from all the locations.

PHYLUM ARTHROPODA von Siebold and Stannius, 1845

Subphylum Crustacea Pennant, 1777

Class Maxillopoda Dahl, 1956

Subclass Copepoda Milne Edwards, 1840

Order Cyclopoida Rafinesque, 1815

Family Lernaeidae Cobbold, 1879

Lernaeid (copepodite – immature form) — CHIBB 115L

The first lernaeid found in the Amazon region was described by Thatcher and Paredes (1985). The description was based on specimens from Peru, but the same species has been found in Manaus, Brazil. In recent years, at least seven native species have been found to occur in South America. *Amazolernaea sannerae* Thatcher and Williams, 1998 is the only lernaeid described parasitizing fish of the genus *Cichla* (Thatcher 2006). It is possible that the lernaeid found in *C. piquiti* from the Lajeado reservoir is an immature form of *Amazolernaea sannerae*.

Subclass Branchiura Thorell, 1864

Family Argulidae Leach, 1819

Genus *Argulus* Muller, 1785

Argulus multicolor Stekhoven, 1937 — CHIBB 116L, 117L

Argulids are ectoparasites of the skin and gills of marine and freshwater fish and are popularly known as 'fish lice'. *Argulus multicolor* parasitizes seven species of fish in the Amazon region (Thatcher 2006). This is the first record of *A. multicolor* parasitizing *C. piquiti* and in another biogeographic region (Tocantins River – Lajeado reservoir).

One of the main challenges of conservation biology is to estimate biodiversity before some species become extinct. In Brazil, only 17.3 % of fish species have had their parasite fauna recorded, indicating that the total parasite biodiversity of fish in the region is grossly underestimated (Luque and Poulin 2007).

In total, six groups of parasites were collected, mainly Platyhelminthes (Monogenea, Digenea and Cestoda) and Nematoda. Among the groups of parasites found, nematodes presented the greatest number of species, with seven. This is due to a low degree of host specificity presented by the group. *Procamallanus* (*Spirocamallanus*) *inopinatus* has already been identified in 51 fish species in Brazil (Eiras *et al.* 2010). Kohn *et al.* (2011) registered a total of 15 species of fish parasitized by *P.* (*S.*) *inopinatus* in the Medium Paraná River. *Contracaecum* sp. (larval stage) was recorded in all localities of the present study. This parasite species deserves special attention because it parasitizes fish as larvae, using it as an intermediate host and then presenting zoonotic potential (Takemoto *et al.* 2009). Other parasite groups such as Copepoda and Branchiura were present in low prevalence and mean intensity of infestation, recorded only in *C. piquiti* from the Lajeado reservoir located in the Tocantins River. In the present study the Digenea *Ascocotyle* sp. and *Sphincterodiplostomum* sp., the Nematoda *Contracaecum* sp. and the Copepoda *Learnaea* sp. were identified only at the generic level due to their larval stages.

In general, biogeographic regions exhibit distinct parasite infrapopulations due to various structural strengths. Furthermore, *C. kelberi* and *C. piquiti* in the recent past were introduced in many Brazilian aquatic ecosystems, which could partly explain these differences of parasite component community of these two host population species. In agreement, Torchin *et al.* (2003) reported a lower parasite diversity in invader regions, where hosts were recently introduced, than in others where they were not, supporting the theory of parasite loss through the invasion process. Kennedy and Bush (1994) argued that the parasite species more easily lost through the invasion process will be the ones more strictly dependent on a narrow range of host taxa to spread out and survive (i.e. more specialized parasites).

Table 1. Parasite component community of *Cichla kelberi* collected in the Jupiá reservoir, Rosana reservoir and Marechal Dutra dam from May 2009 to April 2011 .

PARASITE SPECIES	JUPIÁ RESERVOIR		ROSANA RESERVOIR		MARECHAL DUTRA DAM	
	P (%)	MI ± SD	P (%)	MI ± SD	P (%)	MI ± SD
Ectoparasites						
Sciadicleithrum ergensi (Mo)	–	–	27.58	7.87±13.44	–	–
Gussevia tucunarense (Mo)	–	–	6.89	1	–	–
Gussevia undulata (Mo)	–	–	6.89	1	–	–
Ascocotyle sp. (metacercariae) (Di)	–	–	31.03	5.44±4.79	–	–
Endoparasites						
Proteocephalus microscopicus (Ce)	14.29	25.33±28.92	34.48	10.10±11.57	25	44.50±57.63
Proteocephalus macrophallus (Ce)	–	–	6.89	1	12.50	26±21.21
Sciadocephalus megalodiscus (Ce)	4.76	1		–	6.25	1
Procamalanus (Procamalunus) peracuratus (Ne)	4.76	1	–	–	–	–
Goezia intermedia (Ne)	4.76	1	–	–	–	–
Contracaecum sp. (larvae) (Ne)	52.38	26.36±65.70	3.44	1	37.50	6.83±12.36
Raphidascaris (*Sprentascaris*) *manerti* (Ne)	–	–	3.44	1	–	–

P = prevalence; MI = mean intensity; SD = standard deviation; Mo = Monogenea; Di = Digenea; Ce = Cestoda; Ne = Nematoda.

Table 2. Parasite component community of *Cichla piquiti* collected in the Jupiá reservoir, Itaipu reservoir; Lajeado reservoir and São Salvador reservoir from May 2009 to April 2011.

PARASITE SPECIES	JUPIÁ RESERVOIR		ITAIPU RESERVOIR		LAJEADO RESERVOIR		SÃO SALVADOR RESERVOIR	
	P (%)	MI ± SD	P (%)	MI ± SD	P (%)	MI ± SD	P (%)	MI ± SD
Ectoparasites								
Sciadicleithrum ergensi (Mo)	–	–	66.67	10.44±16.53	92	7.13±6.4	30	4.44±4.61
Sciadicleithrum uncinatum (Mo)	–	–	22.22	3.83±2.99	92	14.13±11.21	23.33	5.29±4.31
Sciadicleithrum umbilicum (Mo)	–	–	–	–	92	66.52±106.91	33.33	4.9±5.36
Gussevia tucunarense (Mo)	–	–	44.44	4.75±5.48	100	293.92±281.97	33.33	65.7±93.74
Gussevia undulata (Mo)	–	–	3.7	1	44	4.91±4.70	–	–
Ascocotyle sp. (metacercariae) (Di)	–	–	3.7	2	72	26.61±43.76	–	–
Lernaea sp. (copepodite) (Co)	–	–	–	–	20	2.6±2.61	–	–
Argulus multicolor (Bra)	–	–	–	–	8	1.5±0.71	–	–
Endoparasites								
Genarchella genarchella (Di)	–	–	–	–	–	–	6.67	2.5±2.12
Sphincterodiplostomum sp. (metacercariae) (Di)	–	–	3.7	4	–	–	–	–
Proteocephalus microscopicus (Ce)	84.62	163.82±338.57	77.78	80.48±116.86	80	211.2±588.65	40	70.83±121.25
Proteocephalus macrophallus (Ce)	15.38	5.5±6.36	70.37	13.11±27.19	40	3.6±3.31	6.67	2±1.41
Sciadocephalus megalodiscus (Ce)	15.38	1	11.11	81±137.7	56	11±12.09	–	–
Procamalanus (Spirocamalunus) rarus (Ne)	–	–	3.7	4	–	–	–	–
Procamalanus (Spirocamalunus) inopinatus (Ne)	–	–	–	–	–	–	3.33	1
Contracaecum sp. (larvae) (Ne)	38.46	29±62.05	59.26	4.38±5.06	88	28±30.46	36.67	3.64±4.52
Cucullanus sp. (Ne)	–	–	–	–	32	3±3.02	–	–

P = prevalence; MI = mean intensity; SD = standard deviation; Mo = Monogenea; Di = Digenea; Co = Copepoda; Bra = Branchiura; Ce = Cestoda; Ne = Nematoda.

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